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ABSTRACT
This study showed the preliminary results of two-dimensional localization of echolocating finless porpoises by two stereo acoustic data loggers, A-tags. We conducted passive acoustic observation from an anchored fishing boat using two separated A-tags. Five echolocating porpoises were tracked during a 1.5-hour monitoring. The estimated swimming speeds of the porpoises matched the previous study, which were measured using bio-logging technique. At least one track of porpoises, however, was considered to contain false localization because the swimming speed was faster than the maximum speed of porpoises. Stationary acoustic monitoring has a limited observation range compared to a moving platform. But it has advantages to be able to easily measure the swimming speed and observe under water movement of underwater porpoises. In the future work, it is necessary to observe wild behavior of this species and evaluate the accuracy of the localization method by using larger sample size.

KEYWORDS: *Neophocaena phocaenoides asiaeorientalis*, two-dimensional localization, data logger, A-tag

INTRODUCTION

Yangtze finless porpoise (*Neophocaena phocaenoides asiaeorientalis*) is the only freshwater population of finless porpoise, living in the middle and lower reaches of the Yangtze River, China (Zhao et al., 2008). The population has been decreasing rapidly during the last several decades and could be extinct in the next several decades if no conservation measures are taken (Wang et al., 2006; Turvey et al., 2007). Long-term and range-wide behavioral and ecological information is necessary to take counter measures.

Two-dimensional passive acoustic localization technique using multi acoustic devices or arrays is effective to monitor the behavior of target phonating animals non-invasively (Janik et al., 2000). It has been applied for a lot of marine mammals, such as bottlenose dolphin T*ursiops truncatus* and harbor seal *Phoca vitulina* (Janik et al., 2000), bowhead whale *Balaena mysticetus* (Clark et al., 2000) and manatee *Trichechus manatus* (Muanke et al., 2007).

Although there are some reports on the behavior of Yangtze finless porpoise in captivity or semi-natural environment (Akamatsu et al., 2002; 2005a; Xiao et al., 2005; 2006), little work on their wild behavior has been conducted. Li et al. (2009) reported the movement of wild Yangtze finless porpoises using a moving passive acoustic platform. In this study, we used a stationary platform to monitor their movement.

MATERIALS AND METHODS

On 10th May 2007, we conducted passive acoustic observation from an anchored fishing boat at the junction of the middle reaches of the Yangtze River and Poyang Lake in south-central China (Fig. 1). Water depth was approximately 3 m.

We used two stereo acoustic data loggers, A-tags (Marine Micro Technology, Saitama, Japan) for the acoustic observation. Each A-tag had two hydrophones, approximately 170 mm apart, which were used to identify the sound source direction. Electronic band-pass filters at the pre-amplification stage were adjusted to 55–235 kHz to match the frequency band of Yangtze finless porpoise sonar signals, which ranges 87-145 kHz (Li et al., 2005). The A-tag is an event data logger that records sound pressure and the time difference in sound arrival between two hydrophones. It does not record the waveforms of received sound. Matching of received sound between two A-tags was possible to compare the changing pattern of inter-pulse intervals and sound pressure level. The detection threshold level of the data logger was set at 136.2 dB (re: 1μPa) in this study. The average sound source level of porpoises is estimated 197 dB re 1 μPa p-p at 1 m in the wild (Li et al., 2009). That means we allowed 60.8 dB propagation loss for detecting signals. Assuming a simple spherical propagation model based on the freshwater values set out by Fisher and Simmons (1977; absorption coefficient of 0.004 dB/m at 125 kHz), the maximum detection distance of the stereo acoustic data logger was approximately 800 m. The specification of A-tag is described in detail in Akamatsu et al. (2005b) and Kimura et al. (2009).

We fixed two A-tags underwater at 1-m depth by the side of anchored boat. Two A-tags were set 9 m apart each other. The hydrophones in the two A-tags were set parallel as shown in Fig. 2. The sound source position was estimated by triangulation of the sound source direction from two receivers shown in Fig. 2 and Eq. (1.a) - (1.d). The tracks of swimming porpoises were obtained from the localized positions at each phonation. We analyzed traces of animals only when more than four positions were obtained otherwise the trace was too short.

Fig. 1 Map of survey area: the convergent area of Poyang Lake and the Yangtze River. The star shows the observation site.

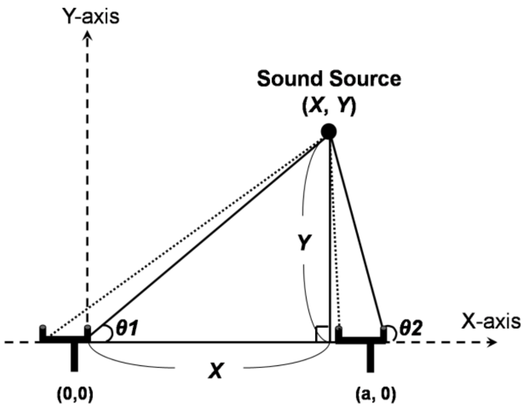

Fig. 2 Geometry of sound source positioning using trigonometry. a was 9 (m) in this study.

$$\tan\theta_1 = \frac{Y}{X} \qquad \text{- (1.a)}$$

$$\tan(180° - \theta_2) = \frac{Y}{a - X} \qquad \text{- (1.b)}$$

$$X = \frac{a\tan\theta_2}{\tan\theta_2 - \tan\theta_1} \qquad \text{- (1.c)}$$

$$Y = \frac{a\tan\theta_1\tan\theta_2}{\tan\theta_2 - \tan\theta_1} \qquad \text{- (1.d)}$$

RESULTS AND DISCUSSION

We obtained 1.5 hours' effective acoustic data by two A-tags simultaneously in 10th May 2007. Of these, tracks of five animals could be monitored acoustically (Fig. 3).

The porpoises often turn around (Akamatsu et al., 2002). The movement path of Fig. 3 (e) might show this type of behavior. The porpoises swam freely but maintained a distance of more than approximately 20 m away from our survey boat. Li et al. (2009) also reported that porpoises did not approach to a moving survey ship within 25m.

The horizontal swimming speeds of the porpoises between the localizations were estimated (a) 1.65±1.31, (c) 0.56±0.30, (d) 0.61±0.19, (e) 1.86±1.47 m/s in figure 3. It was close to the previously observed mean swimming speed, 1.29±0.42 m/s (Akamatsu et al., 2002). The porpoise swims underwater not only horizontally, but also vertically. So the real speed of porpoises may little faster than this. Note that the water depth was shallow, approximately 3m at the observation site. The track of the porpoises shown in Fig. 3 (b) was considered to contain false localization because the calculated swimming speed was occasionally faster than 10 m/s (indicated in the figure) while the max speed of porpoises was 3.74 m/s (Akamatsu et al., 2002).

Passive acoustic monitoring has a limited observation range compared to a moving platform. But it has the advantage to be able to observe the movement of underwater porpoises in the focal area. In the present study, the sample size was small (only five tracks of porpoises). In the future work, it is necessary to observe wild behavior of this species and evaluate the accuracy of it using a larger sample size.

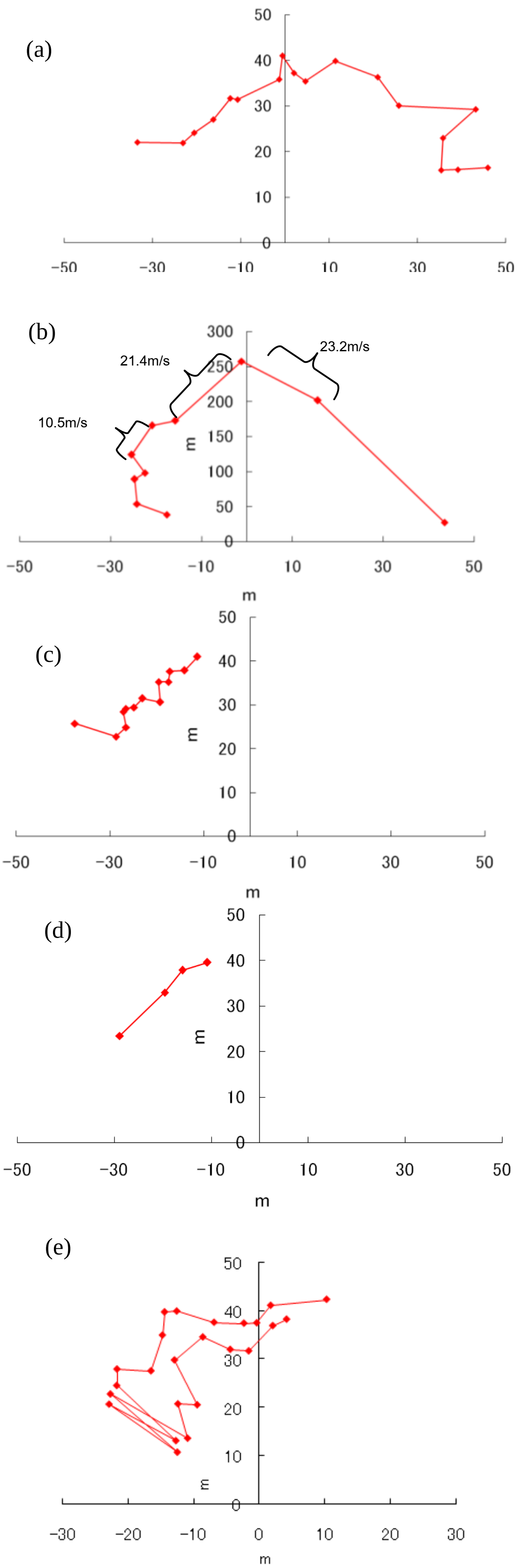

Fig. 3 The tracking paths of echolocating finless porpoises. Two A-tags were located at (0, 0) and (9, 0). The plus and minus number of x axis indicates the side of Poyang Lake, the Yangtze River, respectively. Note that the ranges of y-axis of (b) and (e) are different. Each dot indicates the position of each click train.

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